

FEATURES OF THE VEGETATIVE ANATOMY OF THE AUSTRALIAN
WHITE BEECH (*GMELINA LEICHHARDTII*).

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(Plates xxix-xxxi; nine Text-figures.)

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Introduction.

The Australian White Beech is a large tree. It is a constituent of the luxuriant rain forests of Eastern Australia. In recent years these forests have dwindled rapidly before the penetration of settlement into areas of the continent possessing a bountiful rainfall and fertile soils. Like the majority of the species of the heavy rain forests of eastern and north-eastern Australia the White Beech is allied to Papuan and Malayan types. These Papuan and Malayan types are sharply contrasted with the Australian element of the flora as exemplified by the commoner components of the Eucalyptus and Acacia forests. The genus *Gmelina*, of which the White Beech is a species, is distributed in India, Ceylon, Malaya, South China, the Philippines, Papua and Australia. Three species are found in Australia. The one under discussion, *Gmelina Leichhardtii*, is recorded from as far south as Shoalhaven in New South Wales (35° S.) by J. H. Maiden (1904). The writer has seen it as far north as the Eungella Range in Queensland (21° S.).

Gmelina Leichhardtii is mesophytic in character and in vegetative features possesses little in common with the large section of Australian vegetation which is adapted by xerophytic characteristics to withstand drought, desiccation and the effect of bush fires. The trees in their natural state are now rare, owing to the extent to which the wood has been sought after and the trees felled for commercial timber. In the future the species may be planted extensively in reforestation operations on account of the commercial value of the wood.

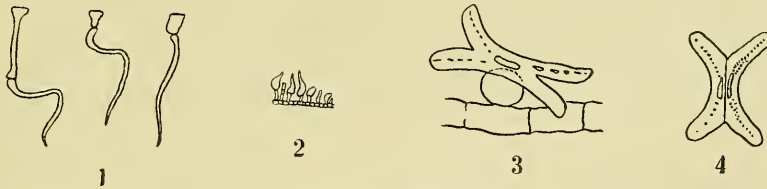
The popularity and economic value of the White Beech are attributable to the qualities of its wood. Although it is neither highly figured nor particularly ornamental, the wood is durable in exposed situations and can be worked with remarkable ease. In view of the extent to which it has been used it seems somewhat remarkable that the timber has not been anatomically described; at least, no microscopical accounts of it have come under the notice of the writer.

In this paper a number of the more important features of the vegetative anatomy of the tree will be outlined. The anatomy of the wood will be described and illustrated as this commodity is an important one from an economic aspect. The microscopical characters thus portrayed will be of value in identifying the wood in critical instances. Features such as the shedding of the bark and the structure and mechanism of the stomata deserve consideration on account of their physiological significance.

Some attention will be given to microchemical subjects. An account of the occurrence and distribution of hesperidin or a hesperidin-like substance and some details of the exact location in the wood of the white deposit known as gmelinol are included. Data of this kind may be of assistance in eventually elucidating the biological functions of these and similar compounds.

THE HAIRY AND GLANDULAR COVERING.

The young shoots, young branchlets and petioles are covered by a fine, but dense, brownish pubescence, consisting of short, blunt hairs. Each hair is situated upon an epidermal cell and consists of 1-5 short cells. When there are more cells than one in each hair the cells are superposed and the terminal cell of each hair is often broad and somewhat expanded (Text-fig. 2). The cell walls of the hairs stain red when treated with an alcoholic solution of Sudan III, indicating that they are cutinized or partly cutinized. The upper surface of the leaf is free of hairs, except on the larger nerves which are sometimes very sparsely clothed with the four-limbed glands shown in Text-figs. 3 and 4. In addition, the leaf surface above the larger nerves in some cases was observed to carry occasional short,



Text-figs. 1-4.—*Gmelina Leichhardtii*.

1. Types of hairs on under side of leaf. $\times 50$.—2. Portion of epidermis and hairy covering of branchlet. $\times 70$.—3. Four-limbed gland on vein on upper side of leaf, viewed partly in profile. $\times 300$.—4. Four-limbed gland on under side of leaf, surface view. $\times 300$.

stellate hairs. The under side of the leaf is furnished with comparatively long, soft hairs which are most abundant on the raised nerves and veinlets. They are mostly composed of two or three superposed cells. The basal cell of each hair is often very short, but sometimes it is elongate (Text-fig. 1). The four-limbed glands illustrated in Text-figs. 3 and 4 are fairly frequent on the under side of the leaves. These peculiar glands are attached to the epidermis by a single globose cell. It is not evident whether these glands serve merely a protective purpose or are concerned with physiological processes such as secretion and exchange of gases.

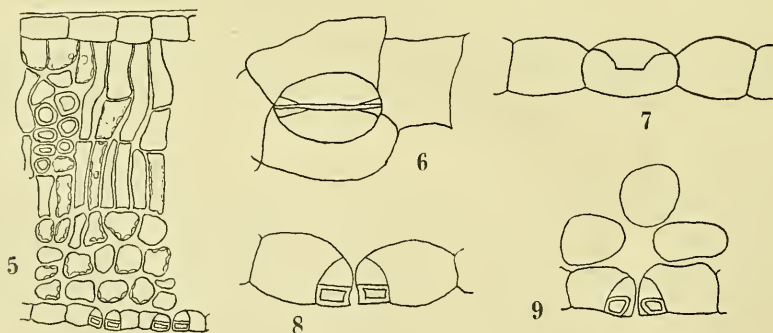
OUTLINE OF ANATOMICAL FEATURES OF THE BRANCHLET, STEM, LEAF AND ROOT.

Branchlets 3-5 mm. in diameter were examined. The epidermis consists of exceedingly small cells which are faintly shown on the outer side of the periderm in the figure of the lenticel (Plate xxix, fig. 4). The most conspicuous feature of the anatomy of the branchlets is the interrupted ring of sclerenchyma between the cortex and phloem. It consists of thickened and lignified bast fibres which in transverse sections often show as semicircular or crescent-shaped groups. A few lenticels occur on the branchlets. They are pale in colour and spindle-shaped in outline. A transverse section of one of them is shown on Plate xxix, fig. 4.

In the bark of the stem of large trees, the interrupted ring of strongly lignified bast fibres which is characteristic of the branchlets has disappeared with the shedding of the outer bark. Scattered groups of thickened and lignified parenchyma cells are fairly frequent (Plate xxxi, figs. 7, 8, 9). Parenchyma, tangential rows of sieve tubes and rays constitute the other tissue elements of the living bark of large trees (Plate xxxi, figs. 7, 8, 9). The outer dead bark consists of tissue elements of the same categories as those of the inner, living bark. It is separated from the inner, still active bark by a continuous layer of cork-like tissue or periderm. This separating or abscission layer will be considered in more detail subsequently. The sieve tubes are in a collapsed condition even in the living bark some distance inwards from the layer of periderm which defines the inner limit of the dead bark.

Apart from the midrib, nerves and veins, the blade or lamina of the leaf is thin and delicate. The venation is strongly raised on the underside of the leaf and imparts firmness to the entire organ. The photograph on Plate xxxi, fig. 10 shows the great degree to which the midrib projects on the underside and the extent to which the midrib exceeds the non-vascular portion of the leaf in thickness. The midrib contains a ring of several collateral vascular bundles. Each vascular bundle is partly enclosed on the outer side by sclerenchyma or thickened tissue which is crescent-shaped in outline in cross sections.

The structure of the non-vascular portion of the leaf blade is diagrammatically represented by Text-fig. 5. Very thick cuticle is absent from both surfaces. The stomata are confined to the lower surface. The structure of the stomata is



Text-figs. 5-9.—*Gmelina Leichhardtii*.

5. Part of section through lamina of leaf. The thickened cells on the upper left represent a small vascular bundle in section. In some of the cells the chloroplasts are shown as appressed to the cell walls. In a few cells the nuclei are outlined. $\times 222$.—6. Stoma, surface view. $\times 700$.—7. Stoma in longitudinal section. $\times 700$.—8. Stoma, transverse section through middle. $\times 700$.—9. Stoma, transverse section towards end. $\times 700$.

diagrammatically shown in Text-figs. 6, 7, 8, 9. The structure of the stomata will be described and its relationship to the movements involved in opening and closing the aperture will be discussed subsequently. All of the stomata seen were of the type illustrated.

The anatomy of the root presents few prominent features. The sclerenchyma on the inner side of the cortex in secondary roots 3 mm. in diameter is much

less conspicuous and decidedly more discontinuous than that in the branchlets sectioned. The periderm on the outer side of the cortex forms a fairly thick sheath.

THE WOOD.

The wood of branchlets, secondary roots and large stems was examined. It consists of wood fibres, vessels, wood parenchyma and rays. The wood fibres are septate and bear simple pits which are more frequent on the radial walls. The vessels are single or in rows of 2-6; the rows are mostly arranged radially. The perforations of the lateral walls of the vessels consist of numerous crowded bordered pits. Tyloses are frequent in the vessels. The wood parenchyma is scanty and generally confined to the immediate neighbourhood of the vessels. The rays are several cells in width (Plate xxx, figs. 5, 6). The freshly-cut wood of large trees is pale or yellowish-white in colour. Its economic properties consist principally of its durability, its freedom from insect attack and the facility with which it can be "worked" by tools. It possesses a principle which attacks iron. Nails which are driven into it are corroded in the course of time. The white deposit which sometimes occurs in the vessels and rays of the mature wood will be dealt with in detail subsequently.

In discussing the durability of the wood the tyloses which are frequent in the lumina of the vessels and the septa crossing the lumina of the wood fibres are to be considered. H. P. Brown (1925, p. 51) states: "Tyloses are indicative of durability in wood because they impede the movement of air and moisture. Fungi and insects are the chief enemies of timber and the former require oxygen and suitable temperature for growth; if these are restricted below the optimum, fungal growth is thereby inhibited. Many of the woods which prove to be durable in contact with the soil and make suitable railway sleepers are featured by abundant tyloses". As the septa in wood fibres exercise a similar impeding effect on the movement of air and moisture they may also be structural factors which promote the durability of the wood of *Gmelina Leichhardtii*. The substance gmelinol which is present in the lumina of the vessels, ray cells and sometimes in the lumina of the wood fibres may have a preservative effect on the wood in a chemical way.

THE STRUCTURE AND MECHANISM OF THE STOMATA.

Sections cut through the middle of a stoma and transversely to the slit or orifice show on each side of the orifice two horizontal cells, one below the other (Text-fig. 8). The walls of the lower cell are thickened. Sections cut in the same plane but towards the ends of the stoma indicate that the cell which was on the lower side in the sections through the middle of the stoma is placed at the outer side and the cell which in the middle of the stoma is on the upper side projects downwards to the lower and inner side (Text-fig. 9). The superficial view diagrammatically shown in Text-fig. 6 demonstrates the position of the cells at the surface of the leaf. The thickening of the walls observed in the lower cell in the section through the middle of the stoma is also noticeable in the same cell when cut towards the ends of the stoma. The two cells shown as the lower ones in the section through the middle of the stoma may be regarded as the guard cells and the two upper ones as the subsidiary cells.

Von Mohl (quoted by Haberlandt, 1914) experimentally demonstrated that changes of turgor provide most, if not all, of the motive power in the process of opening and closing stomata. Among other important factors Schwendener

(quoted by Haberlandt, 1914, p. 448) showed that the peculiar distribution of thickened and unthickened areas in the walls of guard cells under the influence of turgor variations produces important changes of shape which are often requisite to the opening and closing of the orifice of stomata.

The structure of the stomata of *Gmelina Leichhardtii* suggests that the subsidiary cells perform a very important part in the opening and closing of the orifice. Those parts of the subsidiary cells which project downwards to the surface of the leaf towards the ends of the stomata may be specially active in the movements involved in opening and closing. As the turgor of the subsidiary cells increases, these end portions of the cells may expand, press against each other and force the guard cells apart. In this manner the orifices of the stomata may be opened. That the walls of the guard cells are rigid for a great part of their length can be inferred from their thickening. It is possible, however, that the walls of the guard cells may be not thickened at the extremities of the cells and that the extremities of these cells are subject to turgor variations and cooperate with the subsidiary cells in forcing the guard cells apart in the act of opening the orifice. The subsidiary cells may contribute to the opening of the orifice in another way. As their turgor increases their outer lateral walls may be pressed outwards. In this movement the comparatively rigid guard cells would be carried with the outer lateral walls of the subsidiary cells in a direction away from the orifice.

COMPARISON OF ANATOMICAL FEATURES WITH THOSE OF OTHER VERBENACEAE.

The trichomes on the surface of the leaf of *Avicennia nitida* as figured by Solereder (1908) are similar to some of the short hairs on the young branchlets of *Gmelina Leichhardtii* (see Text-fig. 2). The same author (1908, p. 634) also remarks that a composite and continuous sclerenchymatous ring is rarely present in the bark of the Verbenaceae. *Gmelina Leichhardtii* is not an exception in this respect, as the sclerenchymatous ring is interrupted in the bark of the twigs, stem and secondary root. According to a Plate figured by H. P. Brown (1925) the wood of *Gmelina Leichhardtii* resembles that of *Gmelina arborea*, an Indian tree, in possessing septate wood fibres, paratracheal parenchyma and vessels with bordered pits on their lateral walls. The wood of *Gmelina Leichhardtii* resembles that of Indian Teak (*Tectona grandis*) in having septate wood fibres and frequent tyloses in the vessels, but Teak wood is readily distinguished from Australian White Beech by the arrangement of the vessels in interrupted tangential lines in the spring wood, a feature in wood which is often described as ring-porous. E. B. Copeland's figures (1902) of the stoma of *Oxydendrum arboreum* show that its structure is somewhat similar to that of the stoma of *Gmelina Leichhardtii*, but in *Oxydendrum* the guard cells and subsidiary cells are not superposed in the middle of the stoma. From the superficial view the stomata of *Gmelina Leichhardtii* are somewhat similar in appearance to those of the grasses.

THE SHEDDING OF THE BARK.

The bark of the stem is mostly grey in colour and scaly in appearance. The outermost dead bark is cast off in small, rectangular or irregular pieces. The bark measures about 14 mm. (0.6 in.) in thickness on a tree with a stem diameter of 60 cm. (2 ft.). The inner, live bark is pale yellowish-brown in colour and is strongly contrasted with the outer, dead bark which is very dark grey or almost black internally. The dead bark constitutes one-third to one-fifth

of the total thickness of the bark. When the bark is severed from the stem, the outer, dead bark readily separates from the inner bark.

Microscopic preparations show very distinctly the tissue which separates the living from the non-living bark. The region of division between the two kinds of bark is characterized by the development of a prominent layer of periderm which consists of series of horizontally arranged cells. In the outermost part of the periderm the cells are collapsed and pressed together. In the intermediate portion of the periderm a few rows of the cells have thickened tangential walls. When fresh sections of the bark are treated with an alcoholic solution of Sudan III the walls of the entire layer of periderm are stained red. This staining by Sudan III is an indication of the presence of a fat-like substance in the cell walls. The layer of periderm is impermeable to moisture. Through its property of preventing the transfer of solutions it acts as a separation or abscission layer between the inner and outer bark. In this way the cells of the bark on the outer side of the periderm are cut off from the supply of nutrient solutions and severed from active cooperation with the inner, living and generative tissues and in consequence cease to function as living cells. Drying out or desiccation follows upon the death of the outer bark and is accompanied by contraction and cracking.

The fracturing which results from contraction is the cause of the scaliness of the bark. The absence of elongated tissue elements of a hardened character in the bark of large stems facilitates the transverse fracturing which is a part of the processes involved in producing the scales of the bark. The centrifugal pressure developed in stem growth must be a very potent factor in producing longitudinal fractures or fissures in the dead bark. The scales are detached on the inner side along the layers of periderm. As it is often only the outer part of the dead bark on large stems that is cast off, the scales in such cases are freed along layers of periderm which are situated in the outer part of the dead bark. Layers of periderm are produced periodically in the outer part of the living bark and as each layer is generated the layers formed previously are forced outwards.

THE OCCURRENCE AND DISTRIBUTION OF HESPERIDIN.

In the mounted sections of the branchlets conspicuous needle-shaped crystals were observed. These crystals were often arranged in the form of spheres (sphaero-crystals or spherulites), hemispheres, rosettes and paint-brush-like forms. They were yellow or yellowish-brown in colour. Some of the crystal aggregates could be seen in the cells of the pith when sections were freshly cut and mounted on a slide without any medium. From this observation it is concluded that at least some of the crystals probably exist in the plant while it is in the living state. The crystals are insoluble in glacial acetic acid, 50 per cent. hydrochloric acid, concentrated hydrochloric acid, hot and cold water, alcohol, xylol. They are soluble in concentrated sulphuric acid, concentrated nitric acid, 5 per cent. solution of caustic potash and hot glacial acetic acid. H. Molisch (1921) figures similar crystals under the name of hesperidin. The solubility and insolubility of hesperidin in various reagents as outlined by Molisch (1921, p. 183) and Schneider and Zimmerman (1922) correspond fairly closely with the properties of the crystalline substance occurring in the Australian White Beech. It is therefore assumed provisionally that this crystalline substance is hesperidin. Chemical investigation of the substance is necessary for confirmation of this assumption.

The microscopic appearance of the crystal aggregates of hesperidin in the pith of *Gmelina Leichhardtii* is shown in Plate xxix, fig. 3. The crystals were observed, chiefly in mounted preparations, in the cells of the following parts of the branchlet: the pith adjacent to the wood (copious); the vessels of the wood; the phloem and cortex on the inner and outer side of the sclerenchyma groups (fairly abundant); the cambium (less abundant). The crystals were absent from or very scarce in the central portions of the pith. Minute crystals and crystal groups were very abundant in and about the walls of the protoxylem elements (spiral vessels) and the inner vessels of the secondary wood.

In the leaf the crystals were found in the following places: some of the cells of the tissue surrounding the vascular bundles of the midrib, especially on the outer side of the sclerenchyma bands which are situated on the outer side of the vascular bundles; many of the chlorophyll-containing cells of the spongy tissue of the lower side of the lamina; some of the cells of the xylem of the smaller veins. A few crystals were seen in some of the cells of the xylem groups of the vascular bundles in the midrib. The crystals were not seen in the seasoned wood of large trees. Mounted preparations are satisfactory for determining the distribution of the crystalline substance because it is insoluble in the reagents used in preparing the mounted sections.

Hesperidin is a glucoside. According to authorities quoted by F. Czapek (1925) it has been decomposed into hesperetin (or hesperitin), glucose and rhamnose. The same author states that phloroglucin and hesperitic acid have been obtained from hesperitin, that hesperitic acid is identical with m-oxy-p-methoxycinnamic acid and that hesperitic acid yields isovanillin on oxidation. Molisch (1921, pp. 182, 183) states that hesperidin is fairly widely distributed in the Rutaceae, that it also occurs in the Umbelliferae, Labiatae, Scrophulariaceae, Lobeliaceae, Valerianaceae, Lythraceae, Compositae and Papilionaceae.

The hesperidin in the White Beech appears to originate in the spongy tissue towards the under side of the lamina of the leaf. It may be a secondary product of photosynthesis. If it were a primary product one would expect to find it in the palisade cells towards the upper part of the leaf where the photosynthetic activity is presumably greater on account of the more intense illumination. From the lamina of the leaf the hesperidin is apparently transferred to the branchlets through the medium of the vascular system of the leaf. Some of the more minute crystalline aggregates observed in the vessels of the wood of the branchlets possibly represented the compound in course of translocation to other parts of the branchlet or to other parts of the tree.

The distribution of hesperidin is too general to indicate very clearly where it is used. The fact that it contains carbohydrates and an aromatic compound suggests that it may be utilized in the construction of wood. Czapek (1925, 1 Bd., p. 688) states that for a long time aromatic substances have been obtained from wood. The same author (1925, 1 Bd., p. 684) quotes analyses to the effect that the dry substance of various woods consists of 48-56 per cent. of the complex carbohydrate, cellulose.

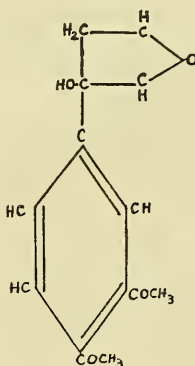
THE LOCATION OF GMELINOL.

The white substance which is often seen in the vessels and rays of the seasoned wood of large trees has been termed gmelinol by H. G. Smith (1912) who investigated it. According to Smith it is crystalline. In the examples examined by the writer no crystals were seen. The material had a granular appearance

and possibly was in the colloidal state. The wood specimens from which the writer's material was taken might have been exposed to conditions different from those to which Smith's samples were subjected. In this way the different states, crystalline and granular (colloidal ?), which were observed by Smith and the writer, may be accounted for. That the material investigated by Smith and that examined by the writer represent the same chemical substance in different states is evident from the similarity in their behaviour towards reagents. The writer found the white material to be soluble in concentrated sulphuric acid, alcohol, ether, xylol and glacial acetic acid. Concentrated sulphuric acid formed with it a dark red solution. It was insoluble in concentrated hydrochloric acid and 5 per cent. solution of caustic potash.

The material was found to be located in the cells forming the tyloses in the lumina of the vessels, in the lumina of ray cells and sometimes in very minute quantities in the lumina of the septate fibres of the wood. It was not found in the young or living parts of the plant, but was observed only in the seasoned wood of large trees. It is probably present in the walls of the tissue of the seasoned wood in a diffused or adsorbed condition as the tissue of old wood was often coloured deep red throughout when acted upon by concentrated sulphuric acid.

Viewed between crossed Nicols the white substance, when separated from the wood and mounted in water, was seen to be strongly doubly refracting. Smith's measurements of the optical activity of the material are given in his paper. He proposed the following structural formula for gmelinol:



There is evidence to indicate that gmelinol is or may be a product of the partial decomposition of the wood. Smith states that the material collects in the cracks of unsound wood. The inclusion of the substance in the cells of the tyloses in the vessels of the wood also indicates that it is at least a secondary product. An additional reason for regarding it as a secondary product is the fact of its absence from the young, freshly-formed wood.

Smith obtained protocatechuic acid from gmelinol by fusion with potash. Protocatechuic acid together with other substances has been obtained from wood by heating it with caustic alkali according to Czapek (1925, 1 Bd., p. 688). The furfuran, which was considered by Smith to constitute the side chain in gmelinol, may be derived from a pentosane of the wood.

SUMMARY.

The structure of the hairs investing the young shoots, branchlets, petioles and under side of the leaves is described and illustrated. The form of peculiar four-limbed glands, which are most frequent on the under side of the leaves, is also dealt with descriptively and diagrammatically.

The occurrence and discontinuity of a ring of hardened bast fibres in the bark of the branchlets and secondary roots between the phloem and cortex are outlined. Fairly frequent groups of thickened and lignified parenchyma cells are remarked upon as constituting the sclerenchymatous elements of the bark of the stem of large trees. The anatomical characters of the mature wood of large trees are detailed. In discussing the durability of the wood the effect of the tyloses and the septa of the wood elements in impeding the movements of air and water is referred to.

Xerophytic characteristics are lacking in the leaves. The stomata are confined to the lower surface. The structure of the stomata is described and illustrated. It suggests that the subsidiary cells perform a very important part in opening and closing the orifice.

The short, blunt hairs of the young shoots and branchlets, the interrupted sclerenchyma ring in the bark of the branchlets and roots and the anatomical characters of the wood are correlated with similar structures in other representatives of the Family.

The appearance and structure of the bark of the stem are described. The physical means by which the outer dead bark is resolved into scales and shed are outlined.

The results of microchemical investigations of the occurrence and distribution of hesperidin or a hesperidin-like substance in the species and the location in the wood of a white substance termed gmelinol are stated. It is suggested that the hesperidin may be a secondary product of photosynthesis and that it may be used in the construction of wood.

Locative and chemical considerations form the basis of a suggestion that gmelinol, which H. G. Smith investigated chemically, may be a partial decomposition product of the wood.

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EXPLANATION OF PLATES XXIX-XXXI.

The photomicrographs are of sections stained with Heidenhain's iron haematoxylin and safranin. Figs. 1, 4, 5, 6, 7, 8, 9, 10 were photographed with a 16 mm. apochromat (N.A. 0.3). Figs. 2 and 3 were photographed with a 4 mm. apochromat (N.A. 0.95). Compensating and periplanatic oculars of various powers were used in conjunction with the objectives.

Plate xxix.

Gmelina Leichhardtii.

Fig. 1.—Transverse section through branchlet 3 mm. in diam. About one-half of the entire section is shown. The uppermost dark irregular band represents the hairy covering of short blunt hairs; beneath it the lighter band consisting of 3-5 rows of cells is the periderm. Below the periderm is the broad cortex consisting of rounded cells with very dark walls. Below the cortex the pale hemispheric or irregularly shaped areas indicate the position of the interrupted sclerenchyma sheath. The dark band below the sclerenchyma shows the position of the phloem; below it the broad, lighter band is the wood (xylem). The white roundish areas in the wood are vessels in section. Following on the wood and occupying the lowermost part of the picture is the pith or medulla; the dark spots in it represent crystal aggregates of hesperidin. $\times 60$.

Fig. 2.—Part of transverse section of branchlet 3 mm. in diam. The uppermost part of the picture shows part of the cortex extending inwards between two groups of sclerenchyma (bast fibres). The walls of the bast fibres are thickened and light in colour. The dark-walled cells occupying the middle of the picture and extending across it from left to right constitute the phloem; the cells in the upper part of the phloem with cut ends showing as roundish apertures consist of phloem parenchyma and sieve tubes; the cells in the lower part of the phloem which are arranged in series and whose cut ends appear somewhat rectangular constitute the cambium or generative tissue. Below the cambium and occupying the lowermost part of the figure is the wood; it is lighter in colour than the cambium. The two large apertures in the wood towards the right are vessels in section. The dark-walled cells in series in the wood constitute the rays. $\times 210$.

Fig. 3.—Part of transverse section of branchlet 3 mm. in diam. showing part of the pith adjacent to the wood. The crystal aggregates (spherulites, etc.) of hesperidin are seen in many of the cells as dark bodies or granules with dark margins. The dark roundish bodies on the lower right show the indistinct images of spherulites of hesperidin which are out of focus. On the uppermost side of the picture the elements of the wood are indistinctly seen. The smaller cells on the upper left are the spiral vessels of the protoxylem in cross section; they are out of focus and show false doubling of the walls. $\times 210$.

Fig. 4.—Cross section of lenticel of branchlet 3 mm. in diam. The pale tissue is periderm. Above the periderm on each side of the broad opening of the lenticel the small-celled epidermis is indistinctly visible; it has dark walls. Above the epidermis the hairy covering is disposed and is represented as a dark confused mass. To the left of the aperture of the lenticel a short hair is shown in which the junction of two cells is shown; the upper cell has a broad base and rapidly tapers at the apex. The layer of dark cells in the opening of the lenticel has stained deeply with the haematoxylin and resembles in this respect the hairy covering. The phellogenetic cells are shown below the pale mass of periderm cells which are situated towards the middle of the lenticel. The dark tissue in the lowermost segment is the cortex. $\times 100$.

Plate xxx.

Gmelina Leichhardtii.

Fig. 5.—Transverse section of mature wood of large stem. The large apertures represent the vessels in section. Projecting inwards from the walls of the vessels are the tyloses. The elongated cells arranged in long lines from top to bottom of the picture constitute the rays. The meshwork of small, roundish apertures shows the wood fibres in section. $\times 120$.

Fig. 6.—Tangential section of mature wood of large stem. The broad irregular pitted band towards the middle of the picture shows a vessel in longitudinal section. The numerous spots on the vessel walls show the positions of the bordered pits. The two slightly oblique lines crossing the vessel are transverse walls. The irregular lines in the uppermost part of the vessel represent tyloses. A small amount of wood parenchyma is shown on the lowermost left side of the vessel. The lens-shaped areas with honeycomb-like pattern are rays in section. The long, wavy dark lines passing from top to bottom are the walls of the wood fibres. The short lines at right angles to the walls of the wood fibres are the septa which cross the lumina or cavities of the wood fibres. $\times 120$.

Plate xxxi.

Gmelina Leichhardtii.

Fig. 7.—Transverse section through the outer bark at the junction of the living and dead tissue. The light, wavy line across the middle of the picture marks the beginning of the abscission (or separation) periderm layer. Above the white wavy line

is the dead tissue. The tissue extending upwards in the figure for about one inch from the white, wavy line consists of periderm. Above the periderm and occupying the uppermost portion is parenchyma with some sclerenchymatous cells at the upper extremity. Below the white wavy line the regularly seriate cells constitute the phellogenetic tissue from which the periderm originates. Two large groups of sclerenchyma are shown on the lowermost and lower left parts of the picture. $\times 40$.

Fig. 8.—Transverse section of the outer living bark on the inner side of the abscission periderm. From and above the middle, large groups of sclerenchyma occupy the picture; the cells in this kind of tissue are only imperfectly defined in the picture. The irregular perpendicular bands on the lower side are the rays of the phloem. The dark, irregular, horizontal lines represent areas of collapsed sieve tubes. The roundish cells composing the ground tissue constitute the parenchyma. $\times 40$.

Fig. 9.—Longitudinal section through the outer bark at the junction of the living and dead tissue. Shows the same tissues as Fig. 7 but in longitudinal section. The abscission periderm is shown as the broad, perpendicular band towards the left. The dead tissue commences at the light portion of the perpendicular band and extends to the left of it. The dark, irregular, perpendicular lines on the right represent areas of collapsed sieve tubes. The lens-shaped area of large cells on the extreme right constitutes sclerenchyma. Smaller-celled sclerenchyma is shown below and to the right of the centre. On the extreme right above the large sclerenchyma cells portion of a phloem ray is represented by small horizontally arranged cells. $\times 40$.

Fig. 10.—Transverse section through midrib of leaf. Several hairs are shown on the exterior. The dark-walled and thick-walled cells beneath the epidermis (of superficial layer of cells) consist of collenchyma. The principal feature of the internal part of the midrib is the ring of eight collateral vascular bundles. The outer side of each vascular bundle is partly enclosed by sclerenchyma which is not shown in detail. The larger, irregularly seriate cells on the inner side of the vascular bundles constitute the xylem. The very minute dark-walled cells of the outer side of the xylem in each bundle form the phloem. The central part of the midrib is occupied by large-celled parenchyma. The large cells between the vascular bundles and the collenchyma also consist of parenchyma. $\times 40$.
